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## VARIATIONS IN CASE FATALITY DURING THE INFLUENZA EPIDEMIC OF 1918.[1]

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In order to determine whether or not the case fatality rate of influenza showed any variation during the course of the 1918 epidemic, and if so, whether this variation bore any relation to the morbidity incidence curve of the epidemic, the data gathered in surveys [2] made by the Public Health Service in 18 widely scattered localities were subjected to analysis from this point of view.

As stated in previous publications,[3] house-to-house canvasses were made of sample areas in these localities [4] immediately after the subsidence of the epidemic in 1918. In two of these localities (Baltimore and San Francisco) recanvasses of the same households were made after the recrudescence of the epidemic in January and February, 1919, and in one (Charles County, Md.) the canvass included the entire population and was made in the early spring of 1919. In these canvasses an enumeration by color, sex, age, and certain other conditions was made of the entire population in the areas selected, and a record, based on statements of responsible persons in each household, was secured of the occurrence of influenza, specifying for each case the date of onset, duration of, and severity of, the attacks, and the date of death in fatal cases.

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[1] From the Statistical Office, United States Public Health Service, in cooperation with Field Investigations of Influenza. Acknowledgments for assistance in the preparation of this paper are made to Miss Mary L. King, of the Statistical Office, and to Mr. Rollo H. Britten, Assistant Statistician for the Influenza Commission, Metropolitan Life Insurance Co. Preliminary data upon which the conclusions in this paper are based were presented before the Vital Statistics Section of the American Public Health Association at New Orleans in October, 1919.

[2] Previous papers bearing on these surveys are:

Influenza in Maryland: Preliminary Statistics of Certain Localities, by W. H. Frost and Edgar Sydenstricker. Public Health Reports, vol. 34, No. 11, Mar. 14, 1919. Reprint No. 510.

The Epidemiology of Influenza, by W. H. Frost. Jour. Am. Med. Assn., vol. 73, No. 5, Aug. 2, 1919. Reprinted in Public Health Reports, vol. 34, No. 33, Aug. 15, 1919. Reprint No. 550.

Statistics of Influenza Morbidity: With Special Reference to Certain Factors in Case Incidence and Case Fatality, by W. H. Frost. Public Health Reports, vol. 35, No. 11, Mar. 12, 1920. Reprint No. 586.

[3] See especially Statistics of Influenza Morbidity: With Special Reference to Certain Factors in Case Incidence and Case Fatality, by W. H. Frost. Public Health Reports, vol. 35, No. 11, Mar. 12, 1920. Reprint No. 586.

[4] New London, Conn., Baltimore, Quantico, Linganore, Frederick, Salisbury, Cumberland, Downsville, Lonaconing, and Charles County, Md., Little Rock, Ark., San Francisco, Calif., San Antonio, Tex., Louisville, Ky., Spartanburg, S. C., Des Moines, Iowa, Macon and Augusta, Ga.

In the analysis presented here the procedure followed was to compute the case fatality rate for as short successive periods of time as the data permitted and to determine as accurately as we could the trend of case fatality during the epidemic.[5] Because of a tendency for cases to be reported as occurring on easily remembered dates, and because of small numbers of deaths by days, the smallest division of time which could be employed satisfactorily was the week. To determine the true weekly case fatality, deaths were necessarily allocated to the week in which the fatal cases had their onset. The weekly case fatality rate for all surveyed localities combined could be carried only through the week ending December 14, since the epidemic had ended by that time in some of the localities and the rates for succeeding weeks, therefore, would be based on those localities only in which the epidemic persisted beyond that date.

In Table I and in Figure 1 are given the weekly fatality rates in all surveyed localities combined. Some irregularity due to small numbers of cases and deaths will be noted. The same irregularity is present in the other fatality data given in this article and has made it desirable to employ a method of smoothing to indicate what appeared to be the general trend of the rates. Accordingly, curves were fitted to the data by the method of least squares.[6] The smoothed rates are included in the table and graph.

TABLE I.—*Influenza case fatality by weeks from Sept. 1 to Dec. 14, 1918, among canvassed persons in all surveyed localities.*[a]

| Week ended— | Cases. | Deaths (by week of onset of case). | Fatality rate per 100 cases. | |
|---|---|---|---|---|
| | | | Actual. | Smoothed. |
| Sept. 7 | 290 | 4 | 1.38 | 0.97 |
| 14 | 298 | 3 | 1.01 | 1.58 |
| 21 | 747 | 12 | 1.61 | 1.93 |
| 28 | 1,338 | 36 | 2.69 | 2.06 |
| Oct. 5 | 5,369 | 110 | 2.05 | 2.08 |
| 12 | 5,851 | 127 | 2.17 | 2.00 |
| 19 | 5,273 | 82 | 1.56 | 1.88 |
| 26 | 3,001 | 58 | 1.93 | 1.73 |
| Nov. 2 | 2,278 | 33 | 1.45 | 1.60 |
| 9 | 1,286 | 18 | 1.40 | 1.48 |
| 16 | 1,787 | 21 | 1.18 | 1.42 |
| 23 | 1,285 | 18 | 1.40 | 1.38 |
| 30 | 1,820 | 34 | 1.87 | 1.37 |
| Dec. 7 | 2,307 | 25 | 1.08 | 1.38 |
| 14 | 1,029 | 15 | 1.46 | 1.39 |

[a] Including only persons of known ages.

[5] The relative importance of pneumonia as a fatal sequela to influenza in successive periods of the epidemic could not be determined with a degree of accuracy to warrant any conclusion because of the small number of deaths when subdivisions into short periods were made and because of the doubtful accuracy of the individual records with respect to this point.

[6] The formula used in this case and in the succeeding cases was $y=a+bx+cx^2+dx^3+ex^4$, $x$ being the interval in weeks from the central point of the series, $y$ the fatality rate for the given week, and $a$, $b$, $c$, $d$, and $e$ constants determined directly from the data. Owing to irregularity at the ends of each series, it was found advisable to average the last two items at either end and replace each of these items with this average. In some instances it seemed desirable, for the same reason, to eliminate the extreme items at either end of the smoothed series.

It will be noted that there was a sharp rise in case fatality at the beginning of the epidemic, that a peak was reached in the week ended October 5, and that after that time the fatality rate gradually fell.

Comparison with the morbidity curve of the epidemic is immediately suggested. In determining the case rates by weeks, account must be taken of the fact that, when a person develops the disease, he is temporarily eliminated from the susceptible population. In calculating the rates for each week, therefore, all cases which had

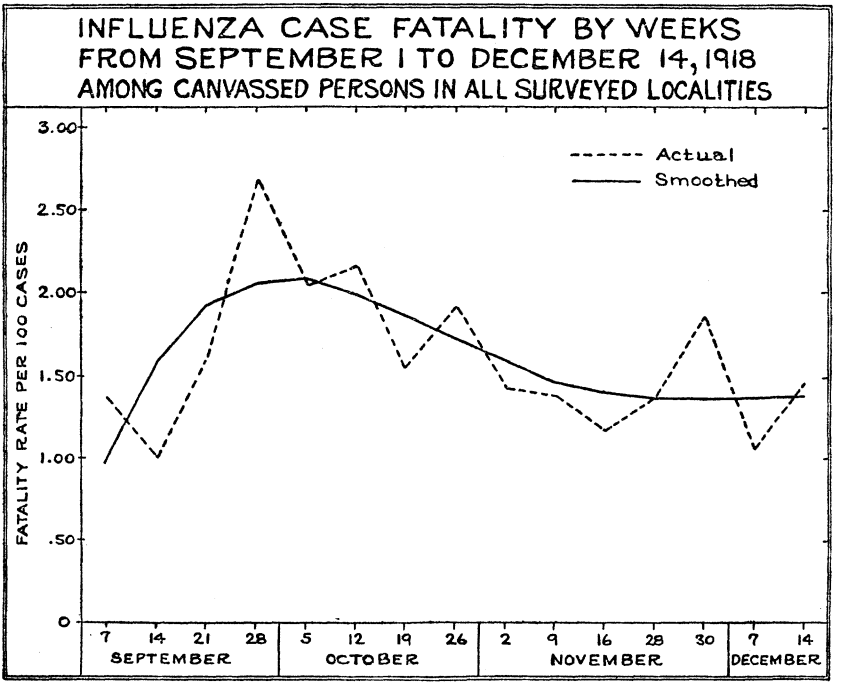


FIG. 1.

occurred during the epidemic prior to that week were deducted from the population. To make the case fatality and case incidence curves comparable, the rates were divided by their respective arithmetic averages. Table II presents the actual case rates by weeks from September 1 to December 14, the fatality rates already presented, and the smoothed indices based on these data.

TABLE II.—*Influenza case incidence and case fatality by weeks from Sept. 1 to Dec. 14, 1918, among canvassed persons in all surveyed localities.*[a]

| Week ended— | Weekly case rate per 1,000 persons. | Fatality rate per 100 cases (smoothed). | Indices. | |
|---|---|---|---|---|
| | | | Case incidence. | Case fatality (smoothed). |
| Sept. 7 | 2.04 | 0.97 | 0.11 | 0.60 |
| 14 | 2.10 | 1.58 | .12 | .98 |
| 21 | 5.29 | 1.93 | .29 | 1.19 |
| 28 | 9.52 | 2.06 | .53 | 1.27 |
| Oct. 5 | 38.56 | 2.08 | 2.14 | 1.28 |
| 12 | 43.70 | 2.00 | 2.43 | 1.23 |
| 19 | 41.18 | 1.88 | 2.29 | 1.16 |
| 26 | 24.45 | 1.73 | 1.36 | 1.07 |
| Nov. 2 | 19.02 | 1.60 | 1.06 | .99 |
| 9 | 10.95 | 1.48 | .61 | .91 |
| 16 | 15.38 | 1.42 | .86 | .88 |
| 23 | 11.23 | 1.38 | .62 | .85 |
| 30 | 16.09 | 1.37 | .89 | .85 |
| Dec. 7 | 20.73 | 1.38 | 1.15 | .85 |
| 14 | 9.44 | 1.39 | .53 | .86 |

[a] Including only persons of known ages.

Figure 2 presents the smoothed curves. It is suggested that there was a definite relation between the stage of the epidemic and its fatality, but no such conclusion is justified without considering two factors: (a) differences in age incidence as the epidemic progressed (which may have been responsible in part or in whole for the changes in case fatality); and (b) the stage of the epidemic in each locality.

With respect to the first point, (1) case fatality of epidemic influenza, as is now well known, varied according to age in a marked and characteristic manner, and (2) analyses of influenza case incidence in specific age groups at successive periods of the epidemic in the surveyed localities have shown that there was a gradual change in incidence in the different ages. Incidence in the age groups up to 15 years was relatively lower in the earlier stages of the epidemic than in the later stages. It is evident that, even if the fatality in the individual age groups remained constant as the epidemic progressed, the fatality rates for all ages would be affected to some extent by changes in the relative incidence of the cases in the different age groups. It was therefore thought advisable to adjust the case fatality rates to a standard age distribution of cases.[7] The data are too meager to permit such adjustment for each week. The adjustment, therefore, has been made for groups of weeks, each period containing approximately one-fourth of the cases occurring in all localities during the epidemic. The actual and adjusted case fatality rates (all known ages) for these groups are compared in Table III.

[7] What was desired was to determine what the fatality rates would be at successive periods, if there were assumed a constant distribution of cases in separate age groups at these periods. In other words, the case fatality rates were adjusted to a standard distribution, not of population, but of cases. For convenience, the percentage distribution of cases in each age group for the whole epidemic in all surveyed localities was used as the standard.

TABLE III.—*Actual and adjusted (for age) case fatality of influenza for four periods of epidemic in all surveyed localities.*[1]

| Period ended— | Cases. | Deaths (by date of onset of case). | Fatality rate per 100 cases. | |
|---|---|---|---|---|
| | | | Actual. | Adjusted for age. |
| Oct. 5 | 8,042 | 165 | 2.05 | 2.00 |
| Oct. 19 | 11,124 | 209 | 1.88 | 1.92 |
| Nov. 30 | 11,457 | 182 | 1.58 | 1.57 |
| Feb. 1 | 8,066 | 128 | 1.59 | 1.59 |

[1] It may noted that the division of cases and deaths into what are practically quartile periods does not afford a true picture of the case fatality curve, as a reference to Tables I and II and Figures 1 and 2 will show.

While the specific morbidity rates were found to differ considerably in the four periods, these differences in case incidence did not

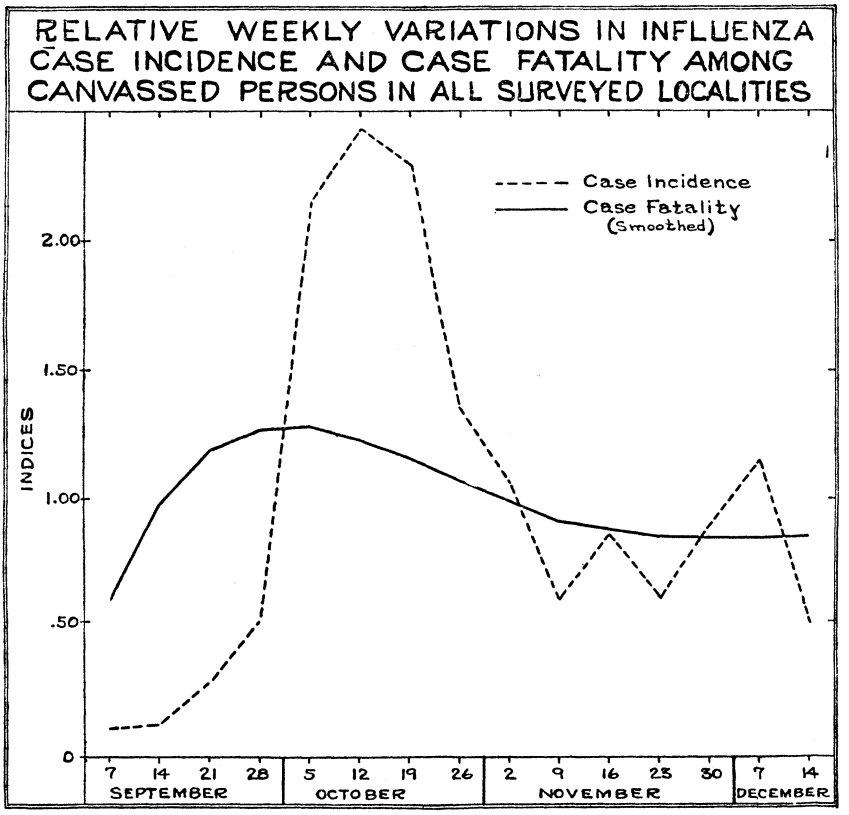


FIG. 2.

affect materially the case fatality rates. The differences shown by the adjustments are negligible, and for this reason the factor of age may be safely disregarded.[8]

[8] The same adjustment for Baltimore alone gave a similar result.

The other point requiring consideration is the stage of the epidemic in individual localities. The grouping of localities in Tables I and II did not take into account differences in the behavior of the epidemic from the point of view of *time*, and the epidemic curves differed widely in their general character. Most of the localities surveyed showed two somewhat clearly defined waves, but the relations which these waves bore to each other were quite dissimilar. In some cases the second peak occurred two or three weeks after the first; in others, months separated the two peaks. In some cases the incidence was greater in the first wave, in others in the second wave. A few of the localities had a single explosive wave. Furthermore, the crest of the epidemic was reached at different times in the various localities. In view of these facts, it seemed desirable to compare the case fatality and case incidence rates in the individual localities for different *periods* of the epidemic. In Table IV a preliminary comparison is made for the period up to and including the date when one-half of the cases had occurred in each locality and for the period after this "median" date.

TABLE IV.—*Influenza case fatality before and after "median" date among canvassed persons in all surveyed localities.*

| Locality. | "Median" date. | Cases. | | Deaths (by date of onset of case). | | Fatality rate per 100 cases. | |
|---|---|---|---|---|---|---|---|
| | | Up to and including "median" date. | After "median" date. | Up to and including "median" date. | After "median" date. | Up to and including "median" date. | After "median" date. |
| All localities | | 21,299 | 21,025 | 419 | 298 | 1.97 | 1.42 |
| New London, Conn | Sept. 30 | 713 | 725 | 22 | 22 | 3.09 | 3.03 |
| Baltimore, Md | Oct. 10 | 4,066 | 4,115 | 108 | 63 | 2.66 | 1.53 |
| Minor Maryland towns[1] | Oct. 8 | 2,380 | 2,669 | 49 | 35 | 2.06 | 1.31 |
| Charles County, Md | Dec. 2 | 3,198 | 3,016 | 75 | 60 | 2.35 | 1.99 |
| Little Rock, Ark | Oct. 10 | 1,782 | 1,734 | 21 | 18 | 1.18 | 1.04 |
| San Francisco, Calif | Oct. 30 | 2,030 | 1,916 | 54 | 36 | 2.62 | 1.88 |
| San Antonio, Tex | ...do... | 3,270 | 3,376 | 35 | 19 | 1.07 | .56 |
| Louisville, Ky | Nov. 1 | 945 | 843 | 16 | 9 | 1.69 | 1.07 |
| Spartanburg, S. C | Nov. 5 | 560 | 559 | 7 | 3 | 1.25 | .54 |
| Des Moines, Iowa | Nov. 23 | 656 | 675 | 12 | 10 | 1.83 | 1.48 |
| Macon, Ga | Nov. 15 | 945 | 726 | 13 | 12 | 1.38 | 1.65 |
| Augusta, Ga | Dec. 16 | 724 | 671 | 7 | 11 | .97 | 1.64 |

[1] Cumberland, Frederick, Salisbury, Lonaconing, Quantico, Linganore, and Downsville.

In 10 of the 12 localities the fatality was higher in the first half of the epidemic. The two exceptions—Macon and Augusta—are localities in which the epidemic curve was quite unique in that the peak did not occur until practically the end of the epidemic.

The small size of the canvassed populations makes it impossible to determine the rates in individual localities for more finely divided periods. To obtain weekly rates it has been necessary to combine the localities, having regard to the character of the epidemic curve in each. Those localities in which there was one sharply explosive

wave (New London, minor Maryland towns, and Little Rock) have been placed in one class, while other localities, in which there were two waves (more or less clearly defined), have been placed in another class.[9] To allow for the difference in time at which the peaks occurred the peak weeks have been placed together. In the second group the peaks of the two waves have been considered separately, one half of the weeks intervening between the two peaks having been arbitrarily placed in the first wave and the other half in the second wave. As before, cases occurring previously have been eliminated from the population before calculating the case rates for each week.[10]

The case rates and the fatality rates for the successive weeks have been reduced to a comparable basis by dividing them by their respective arithmetic averages. The case fatality indices were smoothed by the method previously referred to, and the smoothed figures have been introduced into the tables which follow.

TABLE V.—*Influenza case incidence and case fatality, by weeks, during 1918 epidemic in canvassed populations of surveyed localities with a single explosive peak,[a] the peak weeks having been placed together.*

| Week. | Persons canvassed. | Cases. | Deaths (by date of onset of case). | Case rate per 1,000 persons. | Fatality rate per 100 cases. | Indices. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Case incidence. | Case fatality (smoothed). |
| Weeks prior to peak week: 5 | 22,388 | 28 | 1 | 1.25 | 1.25 | 0.05 | 0.76 |
| 4 | 22,360 | 52 | 0 | 2.33 | | .09 | |
| 3 | 30,240 | 148 | 2 | 4.89 | 1.35 | .19 | 1.08 |
| 2 | 30,092 | 374 | 6 | 12.43 | 1.60 | .47 | 1.22 |
| 1 | 29,718 | 1,963 | 45 | 66.05 | 2.29 | 2.52 | 1.25 |
| Peak week | 27,755 | 2,874 | 52 | 103.55 | 1.81 | 3.95 | 1.20 |
| Weeks subsequent to peak week: 1 | 24,881 | 1,801 | 21 | 72.38 | 1.17 | 2.76 | 1.12 |
| 2 | 23,080 | 819 | 15 | 35.49 | 1.83 | 1.35 | 1.03 |
| 3 | 22,261 | 519 | 10 | 23.31 | 1.93 | .89 | .95 |
| 4 | 21,742 | 246 | 2 | 11.31 | .81 | .43 | .90 |
| 5 | 21,496 | 214 | 1 | 9.96 | .47 | .38 | .88 |
| 6 | 21,282 | 174 | 4 | 8.18 | 2.30 | .31 | .87 |
| 7 | 21,108 | 187 | 3 | 8.86 | 1.60 | .34 | .86 |
| 8 | 20,921 | 146 | 1 | 6.98 | .68 | .27 | .84 |

[a] New London, minor Maryland towns, Little Rock.

[9] One locality (Macon) has been omitted entirely because of the fact that its curve does not strictly fall into either of the two classes mentioned.

[10] It is obvious that at the beginning and end of each series of weeks certain localities will not be represented, and therefore the population of these localities has been deducted from the total before computing rates for those weeks.

TABLE VI.—*Influenza case incidence and case fatality by weeks during 1918 epidemic in canvassed populations of surveyed localities with two waves,*[1] *the peak weeks having been placed together.*

FIRST WAVE.

| Week. | | Persons canvassed. | Cases. | Deaths (by date of onset of case). | Case rate per 1,000 persons. | Fatality rate per 100 cases. | Indices. | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Case incidence. | Case fatality (smoothed). |
| Weeks prior to peak week | 6 | 57,287 | 170 | 2 | 2.97 | 1.18 | 0.19 | ..... |
| | 5 | 90,460 | 252 | 2 | 2.79 | .79 | .18 | 0.49 |
| | 4 | 107,467 | 389 | 5 | 3.62 | 1.29 | .23 | .69 |
| | 3 | 107,078 | 486 | 6 | 4.54 | 1.23 | .29 | .99 |
| | 2 | 106,592 | 1,376 | 30 | 12.91 | 2.18 | .82 | 1.24 |
| | 1 | 105,216 | 3,271 | 91 | 31.09 | 2.78 | 1.97 | 1.86 |
| Peak week | | 101,945 | 4,488 | 101 | 44.02 | 2.25 | 2.79 | 1.30 |
| Weeks subsequent to peak week | 1 | 97,457 | 2,820 | 46 | 28.94 | 1.63 | 1.84 | 1.13 |
| | 2 | 94,637 | 1,872 | 25 | 19.78 | 1.34 | 1.26 | .95 |
| | 3 | 92,765 | 1,216 | 19 | 13.11 | 1.56 | .83 | .92 |
| | 4 | 76,983 | 738 | 19 | 9.59 | 2.57 | .61 | ..... |

SECOND WAVE.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Weeks prior to peak week | 4 | 72,083 | 609 | 9 | 8.45 | 1.48 | 0.62 | ..... |
| | 3 | 84,131 | 1,247 | 9 | 14.82 | .72 | 1.09 | 0.74 |
| | 2 | 88,290 | 1,264 | 16 | 14.32 | 1.27 | 1.05 | .91 |
| | 1 | 87,026 | 1,530 | 24 | 17.58 | 1.57 | 1.29 | 1.13 |
| Peak week | | 85,496 | 2,547 | 40 | 29.79 | 1.57 | 2.19 | 1.25 |
| Weeks subsequent to peak week | 1 | 82,949 | 1,350 | 27 | 16.28 | 2.00 | 1.20 | 1.23 |
| | 2 | 81,599 | 852 | 12 | 10.44 | 1.41 | .77 | 1.09 |
| | 3 | 70,312 | 389 | 1 | 5.53 | .26 | .41 | .93 |
| | 4 | 34,548 | 174 | 4 | 5.04 | 2.30 | .37 | .90 |

[1] Baltimore, Charles County, Md., San Francisco, San Antonio, Louisville, Spartanburg, Des Moines, and Augusta, Ga.

Figure 3 presents the smoothed indices for the one-peak and two-peak cities, respectively.

In forming a judgment as to the significance of the relations brought out in these statistics, it must be borne in mind that near the close of the epidemic, when the number of cases was relatively small, deaths from non-influenza pneumonia may have been sufficient to raise the case fatality to some extent.

Allowing for certain irregularities that apparently are caused by small numbers, the curves presented in Figure 3 suggest that:

1. A distinct rise and fall in case fatality occurred during the course of the epidemic.

2. This change bore a fairly definite relation to the rise and fall in case incidence. The correspondence is especially clear in those cities in which two peaks occurred, and is shown in both waves.

3. Case fatality seemed to rise during the first part of each wave of the epidemic, tending to reach its highest point during the period in which the epidemic was spreading most rapidly, but showing a tendency to decline immediately before or coincident with the peak in incidence.

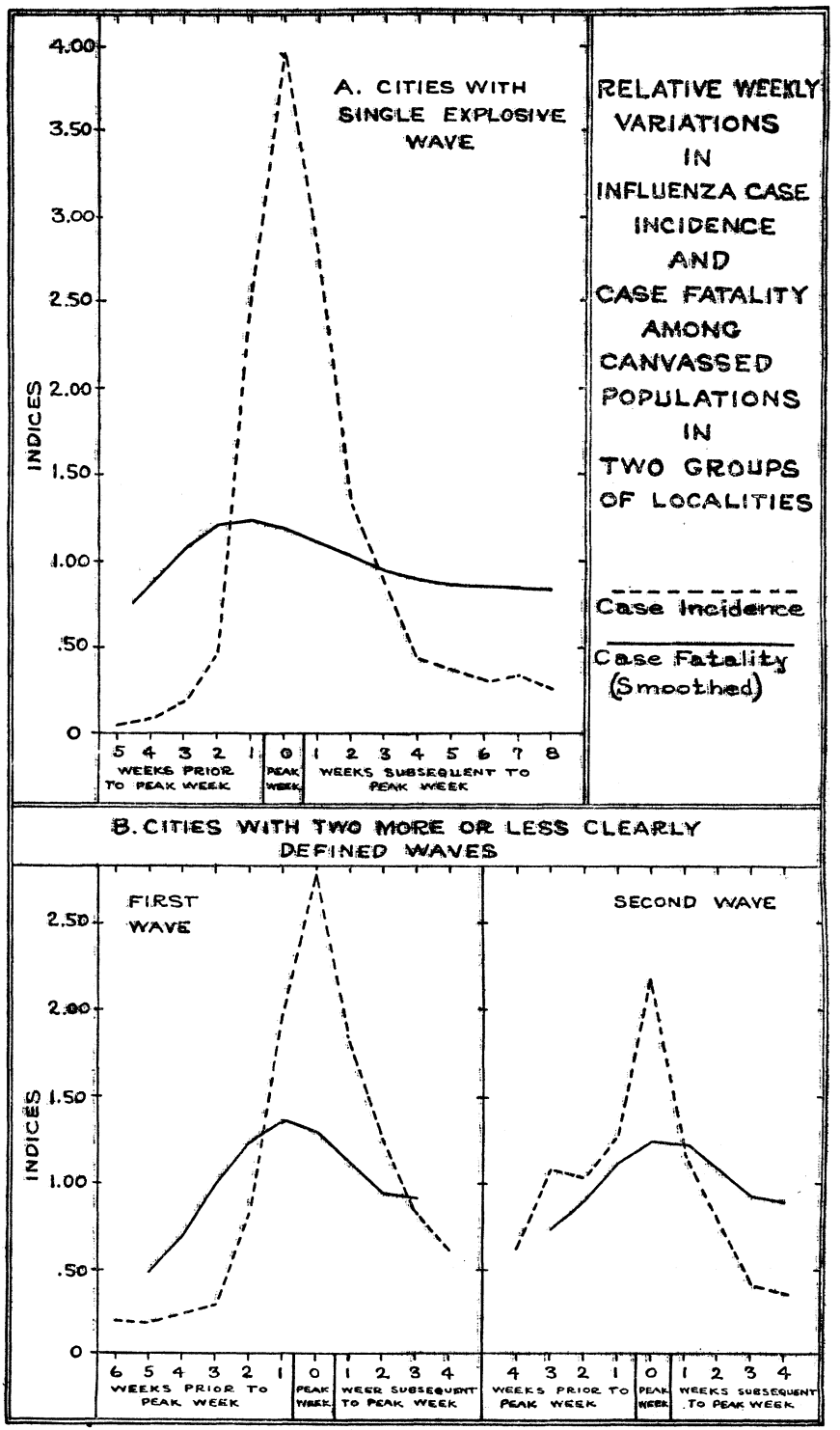
A. CITIES WITH SINGLE EXPLOSIVE WAVE
RELATIVE WEEKLY VARIATIONS IN INFLUENZA CASE INCIDENCE AND CASE FATALITY AMONG CANVASSED POPULATIONS IN TWO GROUPS OF LOCALITIES
Case Incidence
Case Fatality (Smoothed)
INDICES
4.00
3.50
3.00
2.50
2.00
1.50
1.00
.50
0
5 4 3 2 1
WEEKS PRIOR TO PEAK WEEK
0
PEAK WEEK
1 2 3 4 5 6 7 8
WEEKS SUBSEQUENT TO PEAK WEEK
B. CITIES WITH TWO MORE OR LESS CLEARLY DEFINED WAVES
FIRST WAVE
SECOND WAVE
INDICES
2.50
2.00
1.50
1.00
.50
0
6 5 4 3 2 1
WEEKS PRIOR TO PEAK WEEK
0
PEAK WEEK
1 2 3 4
WEEK SUBSEQUENT TO PEAK WEEK
4 3 2 1
WEEKS PRIOR TO PEAK WEEK
0
PEAK WEEK
1 2 3 4
WEEKS SUBSEQUENT TO PEAK WEEK

FIG. 3.

These results at least indicate that for the cases observed there was a variation in fatality, particularly during the period of greatest prevalence.

A number of explanations at once suggest themselves for consideration. It is possible that there was a difference in the degree of care given patients at different periods of the epidemic. It is also possible that a selection may have resulted from a tendency for the least resistant to come down with the disease first, or that there was a change in the virulence of the disease during the epidemic. The present data, however, do not assist us in an interpretation beyond suggesting that some relation existed between the variations in case fatality and the curve of epidemic case incidence.

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## CONTROL OF VENEREALLY DISEASED PERSONS IN INTERSTATE COMMERCE.

By DAVID ROBINSON, United States Public Health Service.

The apprehension, isolation, and treatment of persons infected with a venereal disease are generally matters for State or city action. Enforcement of State laws, or regulations of State boards of health or city ordinances on the subject of the spread of contagious diseases is usually sufficient to prevent a venereally diseased person from spreading his disease.

There are times when an infected person will escape the jurisdiction of a State which is enforcing rigidly the quarantine laws and venereal disease control laws and will flee to another jurisdiction where the health authorities are not so vigorous in enforcing laws directed against the spread of venereal diseases.

The Federal Government has but little power to control the spread of diseases in the States. The Government has, however, exercised the power given to it under the Constitution to regulate commerce between the States and between this country and foreign countries by passing, from time to time, laws which have for their object the prevention of the spread of contagious diseases in interstate commerce.

In addition to the enactment of certain statutes, Congress has authorized the Secretary of the Treasury to promulgate regulations to prevent the spread of contagious diseases in interstate commerce. Acting on this authority, the Secretary of the Treasury promulgated the Interstate Quarantine Regulations controlling the spread of contagious diseases from one State to another, and on November 19, 1918, there was added Amendment No. 7 to these Interstate Quarantine Regulations, said amendment being regulations for interstate travel of venereally infected persons.